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## Growth of Chinese Sparrowhawk *Accipiter soloensis* nestlings

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### Introduction

Being able to estimate the age of individual nestlings is essential for various raptor studies, monitoring and conservation. Since the increase in body measurements of raptor nestlings follows a predictable pattern, it is often possible to estimate the age of nestlings by fitting measurements of a given parameter to a growth curve of known form (Starck & Ricklefs 1998, Hardey *et al.* 2006). Information on nestling growth and best-fitting models of growth has been collected for many raptor species and populations, and used for reliable ageing and sexing, as well as for ecological studies of raptors (e.g. Moss 1979, Bortolotti 1984, Bortolotti 1986, Negro *et al.* 1994, Viñuela & Ferrer 1997, Arroyo *et al.* 2000).

The Chinese Sparrowhawk *Accipiter soloensis* occurs in a wide geographic range throughout East and South Asia as a long-distance migrant (Ferguson-Lees & Christie 2001). However, little information on the growth of nestlings has been recorded because of its relatively confined breeding range in Korea and China (Ferguson-Lees & Christie 2001, Choi *et al.* 2013). Only two previous studies reported simple and general changes in nestling growth (Kwon & Won 1975, Park *et al.* 1975), but they did not provide any growth model for ageing nestlings. Hence, a growth model for this species is desirable to facilitate further studies that require estimation of nestling age. The objective of this study was to give an account of the growth of young Chinese Sparrowhawks by describing their general appearance, measuring nestlings of known age, and selecting the best-fitting growth model for the accipiter.

### Methods

We searched for nests of Chinese Sparrowhawks in June and July from 2005 to 2008 at Gwangju (37.450°N 127.283°E), Gyeonggi province, Republic of Korea, and identified the breeding status of nests we found. We visited the nests daily or used video surveillance systems comprising camcorders (Panasonic NV-MX5000), infrared CCTV cameras (IEVision, IVT-26IRS; Samsung, SIR-4150) and DVD/DVR recorders (Samsung SV-DVR350; Gyungil Electronic Co., DR-554N) to identify hatching dates.

We measured six parameters (body mass, wing, tail, bill, head and tarsus length) of 16 nestlings from five nests. General measurement procedures, as described in Baker (1993) and Hardey *et al.* (2006), were used. Body mass was weighed to the nearest 0.1 g using a portable electronic scale when nestlings weighed <100 g (HS-120, Ohaus Corp., NJ, USA) and to the nearest 0.5 g using a spring scale when the weight exceeded 100 g (Medio-40310, Pesola AG, Baar, Switzerland). Wing length and tail length were measured to the nearest 0.1 mm using a thin metal ruler. We tried to measure maximum wing length, although it was not always possible especially when the nestlings were young and the feather sheaths remained. Tarsus length, head length and bill length (measured from bill-tip to the distal part of the cere) were recorded to the nearest 0.01 mm using a digital vernier caliper (Digimatic 500-181, Mitutoyo Corp., Kawasaki, Japan).

All measurements were taken in the late afternoon between 16h00 and 18h00 to avoid any potential bias caused by measurements

at different times of day e.g. body mass changes resulting from short-term fluctuations in food supply (Hardey *et al.* 2006). To avoid premature fledging, most measurements on nestlings (53/58 measurements; 91%) were taken during the 15 days after hatching. Since sexual dimorphism is small, even in adults of this species (Kemp & Crowe 1994, Choi *et al.* 2013), we did not identify the sex of nestlings.

As growth in nestling body parts was best explained by logistic growth curves, the logistic curve was estimated following Starck & Ricklefs (1998):

$$W=A/[1+\exp(-K(t-t_i))] ]$$

where  $W$  = the growth variable,  $A$  = asymptote,  $K$  = the growth rate constant,  $t$  = age of nestling, and  $t_i$  = the inflection point of the growth curve.

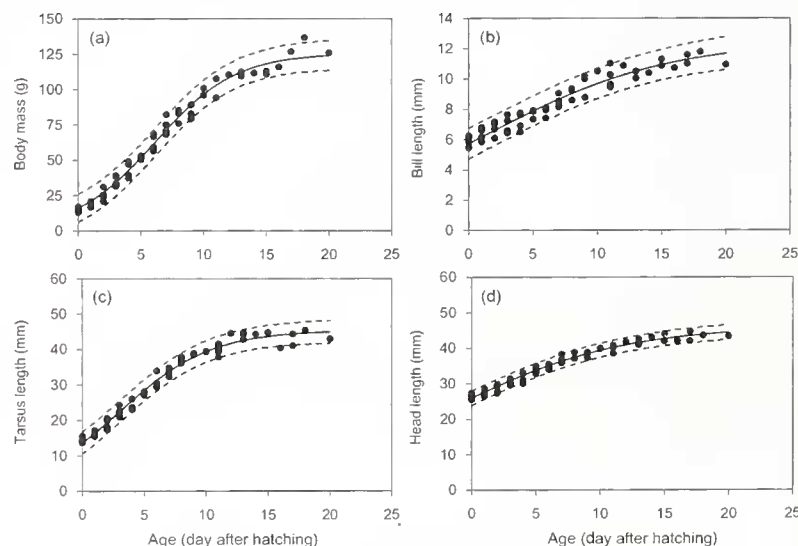
We measured wing (maximum wing length) and tail of 14 birds (seven males and seven females) in first summer plumage (1S), captured at stopover sites on spring migration in May 2007 and 2008, to provide asymptotic values for growth models. Because the sparrowhawks do not moult their flight and tail feathers in their first year, these measurements may represent the mean size of approximately 60-day-old birds, when they first start their migration south. We ignored the potential effects of abrasion on feather length and possible size changes of structural parts during their first winter.

SAS 8.1 software (SAS Inst. Inc., Cary, NC, USA) was used for statistical analyses, and the constants for the logistic growth curve were calculated from a non-linear procedure (PROC NLIN) in SAS.

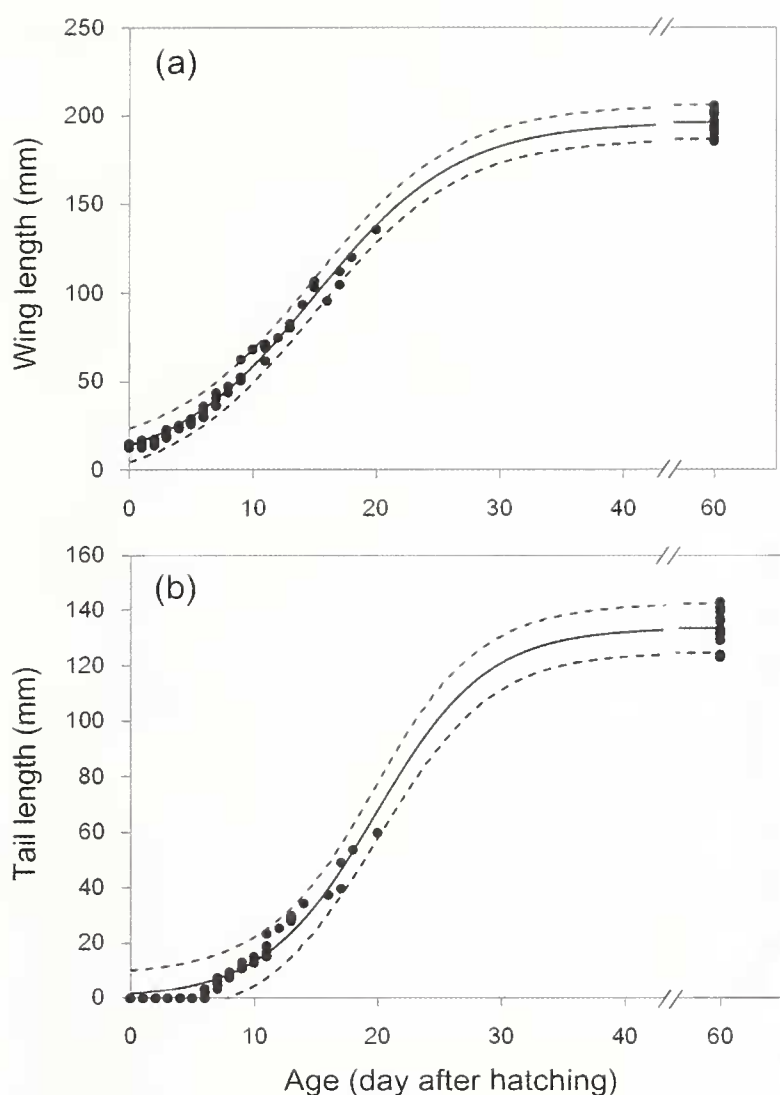
### Results

The growth curves and the model predictors of the parts measured are presented in Figures 1 & 2 and Table 1. The inflection point of the body mass curve, indicating the time of highest growth rate,

**Figure 1.** Growth in (a) body mass, (b) bill length, (c) tarsus length, and (d) head length of 16 Chinese Sparrowhawk nestlings from five nests. Solid lines indicate the logistic growth curves, and dashed lines represent upper and lower 95% confidence levels.







**Figure 2.** Growth in (a) wing length and (b) tail length of 16 Chinese Sparrowhawk nestlings from five nests. Tail and maximum wing length of 14 sparrowhawks (seven males and females) in first summer plumage were used for the growth curve development to compensate for the lack of measurements between fledging (when approximately 20–25 days old) and first migration (when approximately 60 days old). Solid lines indicate logistic growth curves, and dashed lines represent upper and lower 95% confidence levels.

occurred six days after hatching (Table 1). The highest growth rates of wing and tail, which were not fully grown before fledging, were recorded 15 and 20 days after hatching, respectively (Table 1).

Newly hatched nestlings ( $n = 5$ ) had a head length of  $26.57 \pm 0.89$  mm, a bill length of  $5.83 \pm 0.36$  mm, a tarsus length of  $14.67 \pm 0.82$  mm, and a wing length of  $13.7 \pm 1.0$  mm, although there were no remiges or rectrices. Mean body mass on the day of hatching was  $14.5 \pm 1.7$  g, but was dependent on food delivery to new hatchlings, which start begging for food within an hour of hatching; hatchlings which were fed weighed 15.4 g and 17.1 g, whilst unfed ones weighed 13.1–13.5 g. Hatchlings have pink cere, legs and tongue, and white claws; an egg-tooth is present (Plate 1).

**Table 1.** Main growth variables and logistic growth curve parameters with their standard errors (se) of nestling Chinese Sparrowhawks *Accipiter soloensis*.

A = the asymptotic value (unit: g for body mass, mm for others), K = the logistic growth constant ( $\text{day}^{-1}$ ),  $t_i$  = the age (days) of the inflection point.

Growth variables	A (se)	K (se)	$t_i$ (se)	$r^2$
Body mass	125.60 (2.37)	0.3116 (0.0140)	6.136 (0.185)	0.983
Head length	46.07 (0.80)	0.1515 (0.0107)	-1.650 (0.208)	0.972
Bill length	12.53 (0.55)	0.1394 (0.0164)	1.229 (0.593)	0.931
Tarsus length	45.38 (0.62)	0.2729 (0.0125)	3.090 (0.146)	0.980
Wing length	196.42 (1.27)	0.1721 (0.0041)	14.976 (0.167)	0.995
Tail length	133.48 (1.15)	0.2231 (0.0113)	19.846 (0.344)	0.993

Three-day-old nestlings did not demonstrate any alert behaviour to the approach of researchers, but begged for food. Wing feather sheaths emerged three days after hatching and six- to seven-day-old nestlings had distinctly visible wing feather sheaths and bluish-grey claws, and began defensive behaviour against intruders. The cere was greenish yellow (Plate 2).

Nine-day-old nestlings maintained an upright sitting posture on the nest or stood up for a short time. These nestlings still had egg-teeth, and the colour of their claws changed to dark grey. Flight feathers protruded out of sheaths, like a paint brush, at this age and tail feather sheaths that emerged seven days after hatching were clearly visible (Plate 3). Eleven-day-old nestlings had yellow feet

**Plate 1.** Nest 1 – new hatchlings and eggs of Chinese Sparrowhawk *Accipiter soloensis*, 14 July 2005



**Plate 2.** Nest 1 – eight- (right two), seven- (left bottom), and six- (left top) day-old nestlings, 21 July 2005.



**Plate 3.** Nest 1 – nine- (central two), eight- (right), and seven- (left) day-old nestlings, 23 July 2005.





and cere, and some retained the egg-tooth. At this age, the tip of tail feathers protruded from sheaths.

Dark contour feathers were visible over white down feathers at scapulars, breast and flanks in 14-day-old nestlings, and the egg-tooth was normally absent. Claws and tongue were slate-black. As this age, nestlings could remain in a standing posture on the nest, and were exposed to rain without the adult female's protection (Plate 4). Seventeen-day-old nestlings had some visible juvenile feathers on the sides of breast and flanks, and dark contour feathers began to cover the upperparts whereas their heads were still covered by down (Plate 5). At 20–21 days young sparrowhawks were almost covered by contour feathers except for the forehead,

**Plate 4.** Nest 2 – one 15- (centre), two 14- (left and right), and one 13- (bottom) day-old nestlings, 19 July 2005.



**Plate 5.** Nest 1 – three 16- and 17-day-old nestlings, 31 July 2015.



**Plate 6.** Nest 1 – three 20- and 21-day-old nestlings on a branch supporting their nest, 4 August 2015.



central belly and tibia; they spent time on branches around their nest, but frequently returned to its shelter (Plate 6).

## Discussion

Knowledge of growth curves is very useful for estimating the age of a nestling from a single measurement taken in the field (Hardey *et al.* 2006). In particular, the logistic equation most frequently provides the best fit for avian growth data, including raptors (Starck & Ricklefs 1998, Hardey *et al.* 2006). In this study, six growth curves were produced from the measurements of six given parameters (body mass, bill, head, tarsus, wing and tail length) with age, and the logistic curves as predictors of nestling age fitted the growth of young Chinese Sparrowhawks well. Sexing nestlings based only on external measurements is probably impractical because of the considerable extent of overlap in measurements between male and female Chinese Sparrowhawks, even in adults (Choi *et al.* 2013), and because this species has the lowest level of sexual size-dimorphism index among 45 accipiter species (Kemp & Crowe 1994). Nevertheless, this study is the first to provide quantitative information and descriptions on the growth of sparrowhawk nestlings.

Our data suggest that all measured parts may be useful for estimating the age of sparrowhawk nestlings, by fitting them to the developed growth curves, for two weeks after hatching at least. As body parts rapidly grow towards their asymptotes, from this stage onwards, sparrowhawk nestlings may be aged using wing and tail lengths even after fledging. Body mass is a major and general determinant of growth rate in birds (Ricklefs 1968); compared with other structural measurements of nestling growth, however, body mass is also variable and can be affected by detrimental conditions such as food shortage (Starck & Ricklefs 1998, Hardey *et al.* 2006). For instance, one chick which had been fed was heavier than two unfed siblings on the day of hatching in this study. Considering the high predictive power of wing length ( $r^2 = 0.995$ ) and tail length ( $r^2 = 0.993$ ) and the longer period over which they both grow, it is recommended that wing and tail lengths are the best estimators of nestling age in Chinese Sparrowhawk, although tail measurements are not feasible until the rectrices first appear.

In conclusion, the age of sparrowhawk nestlings can be predicted based on the growth patterns of six morphometrics, particularly wing length. We suggest that the growth model estimated from our results and appearance descriptions may benefit further studies on the poorly documented Chinese Sparrowhawk.

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## Species rank of Isabela Oriole *Oriolus isabellae* and White-lored Oriole *O. albiloris* reinforced by song playback responses

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### Introduction

The Isabela Oriole *Oriolus isabellae* and White-lored Oriole *O. albiloris* are endemic to Luzon, northern Philippines (BirdLife International 2014). Historically, the Isabela Oriole was observed in two distinct locations: the northern Sierra Madre mountain range in north-east Luzon and the Bataan Peninsula in western Luzon (Collar *et al.* 1999). However, the species has been reported only three times since 1961, namely (1) 15 km south of Diffun, Quirino province (Gamauf & Tebbich 1995); (2) Mansarong, Baggao, Cagayan province (van der Linde 1995)—neither of which were considered absolutely certain (Collar 1998)—and (3) Ambabok, San Mariano, Isabela province (van Weerd & Hutchinson 2004), all in north-east Luzon. There have been no records from the Bataan Peninsula since 1947 (Collar *et al.* 1999). The current population size of the Isabela Oriole is estimated at fewer than 250 individuals and it is therefore classified as Critically Endangered (BirdLife International 2014). The White-lored Oriole is widely distributed throughout northern Luzon with a population estimated to be greater than 10,000 individuals and it is classified as of Least Concern (BirdLife International 2014). The two species historically occurred sympatrically in the northern Sierra Madre and the Bataan Peninsula (van Weerd & Hutchinson 2004, Collar 2011). Little is known about the ecology of either species except that they are canopy-dwellers and may be associated with secondary forest and forest edge.

Isabela and White-lored Orioles differ in plumage colour, bill length (Collar 1998) and vocalisations (van Weerd & Hutchinson 2004). Isabela Oriole has a stout grey bill, mean length 28 mm, and yellowish lores, while the White-lored Oriole has a slender red bill, mean length 21.8 mm, and broad white lores (Collar 1998). There is little sexual dimorphism in either species (Kennedy *et al.* 2000). The songs of the White-lored Oriole are longer and more tonal or 'flutier' than those of the Isabela Oriole (van Weerd & Hutchinson 2004). Despite these differences the two species show limited DNA sequence divergence, leading to the suggestion that they should 'perhaps' be considered 'a single taxonomic unit' (Jönsson *et al.* 2010). Collar (2011) disagreed with this and argued that the morphological differences, in combination with the historical sympatric occurrence in at least two locations, are sufficient to consider the Isabela and White-lored Oriole as distinct species, which is also in concordance with a recently proposed method for delimiting species (Tobias *et al.* 2010). Clearly, with the Isabela Oriole

currently classified as Critically Endangered it is imperative that its taxonomic status is unambiguous. To that end, we conducted playback experiments with both species to test whether they discriminate between each other's songs.

### Methods

We used playback experiments to test the hypothesis that the Isabela and White-lored Orioles differentiate between conspecific and allospecific song. Females are expected to discriminate between con- and allospecific stimuli if the consequences of hybridisation are maladaptive (Nelson & Soha 2004). However, females do not respond readily to playback in the field, which prevents testing females (Catchpole & Slater 2008). Therefore, most studies that test species recognition use territorial males as subjects (de Kort *et al.* 2002, Seddon & Tobias 2010). Playback of conspecific songs simulates a territorial intrusion and usually leads to an aggressive response from the territory owner (de Kort & ten Cate 2001, Slabbekoorn & Smith 2002). Playback of territorial songs of allospecifics in general tends to produce lower or no response by a territory owner, especially when two species are sympatric (Falls 1988, de Kort & ten Cate 2001, Catchpole & Slater 2008). Playback of bird songs is therefore a useful method to test for biologically relevant species limits (Alström & Ranft 2003).

If Isabela and White-lored Oriole males discriminate between conspecific and allospecific vocalisations, we infer that females will also respond differentially to the songs of the two species. This would suggest that vocalisations can act as a mating barrier and provide support for the current classification of the two orioles as distinct species.

### Study sites

Data were collected in three geographically separated areas: the Sierra Madre, Bataan Peninsula and Northern Cordillera (Figure 1).

The two species occur sympatrically in lowland dipterocarp forest in the San Mariano municipality, Isabela province (17°N 122.167°E), in the northern Sierra Madre. San Mariano is situated on the western edge of the Northern Sierra Madre Natural Park.

The Subic Forest Watershed Reserve (14.750°N 120.333°E) and Bataan Natural Park (14.700°N 120.367°E), both in Bataan province, are located within the Bataan Peninsula. White-lored Oriole is frequently observed in the Bataan Peninsula, but the Isabela Oriole